

# A Study on Q&A Services Between Community-based Question Answering and Collaborative Digital Reference in Two Languages

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## Abstract

To explore further improvement of libraries' reference services in the Web 2.0 environment, we systematically compared community-based question answering (cQA) sites with collaborative digital reference (cDR) services in both English and Chinese languages. We employed a sampling method where we asked a set of questions of four different types and in three domains at selected cQA and cDR sites. The focus of the study includes evaluation of the answer quality and the responsiveness of the sites to the questions. Our results show that cQA sites provide more answers within shorter response times, and they are probably better suited to answer questions about everyday life or questions with easy answers. In contrast cDR services are augmented by better trained librarians, well organized working procedure, and more extensive information sources, so they produce more effective services. We finally hypothesize ideas of combining cQA and cDR under the goal of further improving cDR services.

**Keywords:** community-based question answering sites, collaborative digital reference services, social web

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## Introduction

Community-based question & answering (cQA) sites achieve knowledge sharing among community users through a participatory platform where users can ask and answer questions for each other (Shah, et al., 2009). Since the first cQA site appeared in Korea in 2002, these services have been developing at a very fast pace in many parts of the world. For example, Yahoo! Answers, as by far the most widely used cQA site, had a reported 62 million unique visitors per month in the United States alone in 2010 (Gazan, 2011). As iResearch's latest survey results show (iResearch), the total number of user accesses on Chinese cQA platforms in April 2010 was more than 2.26 billion times, and it is 1.4 times larger than that of the same period of the year before. All these demonstrate that cQA services have expanded to meet a wide range of people's information needs, and more importantly, cQA services have been viewed as rapidly developing social collaboration platforms (Shah, et al., 2009).

Collaborative digital reference (cDR), as stated on the American Library Association's website<sup>1</sup>, "extends a library's information service capability through interaction with other libraries or information centers". Based on formal established protocols, different libraries and information institutions in cDR work together to provide assistance (online reference and remote document delivery) to users to meet their information needs. Reference librarians and users in those services may come from the same library or sister libraries. As with other forms of online services, the reference services are often conducted via both form-based and live chat-based online reference. With the support of cDR, reference librarians with

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<sup>1</sup> <http://www.ala.org/rusa/contact/rosters/rss/rus-moucoop>

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different areas of expertise and working schedules can learn from each other and help each other to better allocate resources according to users' needs (Wang, 2007).

Community-based Q&A and digital reference (which includes cDR as a special case) are two instances of social question and answering because they both enable people to collaborate in answering questions (Shah, et al., 2009). It is important and interesting to study the differences and connections between these two services. More importantly, as one of cDR's major challenges is to expand the services to wider ranges of users, it is beneficial to explore the integration of some cQA's ideas and functions into cDR to enable cDR to serve even more diverse groups of web users.

In this paper, therefore, we will study a set of cQA sites and cDR services to examine their differences and similarities. In addition, because of our backgrounds, we are interested in exploring the differences between Chinese sites and those services based on English. To achieve these research objectives, we designed our study as a comparative analysis of several representative cQA sites and cDR platforms, and deliberately selected both cQA and cDR sites in Chinese as well as in English. We aim to learn more from the effective practices in cQA sites, and to improve libraries' reference services in Web 2.0 environment.

In the remainder of this paper, we will first review the literature, then discuss the research design of our study, in which a set of selected cQA and cDR sites will be briefly presented. Next, we will describe the results obtained from the studies, discuss obtained insights about the differences and the connections between cQA and cDR services, and explore ideas for applying cQA functions in cDR. Finally we will end with our conclusions and thoughts on future work.

## Related Work

Community-based question and answer (cQA) is also known as social QA in the literature (Gazan, 2011). Ever since Knowledge-iN launched in 2002 in South Korea as the first cQA, the study of cQA has been an active research topic, which can be classified into two categories (Shah, et al., 2009). The first research area focuses on the user generated content, such as questions and answers, and pays particular attention to the quality of the answers. For example, by analyzing 81 questions they posed in Yahoo! Answers, Su et al. (2007) demonstrated that the answer quality in the cQA site varied widely. Harper et al. (2008) compared the quality of answers in cQA to those of other types of online Q&A services, such as digital reference services and expert services, and found that cQA answers are perceived as being of higher quality. Liu et al. (2008) examined answers in cQA, found that user satisfaction is an important quality factor, and thus developed several algorithms to predict user satisfaction with the answers.

The second area of research is on users in cQA, which include questioners, answerers and the cQA community as a whole. But majority of the studies paid attention only to questioners and answerers. Gazan (2006) classified the answerers as being either specialists in a particular topic or synthesists who can combine several schools of thoughts and knowledge into one coherent presentation. He found that questioners prefer both types of answerers in order to balance between expertise and information in received answers. Interestingly, studies also showed that answerers select questioners as well, and prefer to respond to the questioners who actively seek for information (noted as seekers) rather than those who just want some ready text for completing tasks such as class assignments (denoted as sloths) (Gazan, 2007). There are many works on identifying authoritative users in the community (Bouguessa, Dumoulin, & Wang, 2008; Jurczyk & Agichtein, 2007).

Digital reference extends traditional library reference services into the Internet environment, and it has resulted in a great deal of discussions (Janes, 2002; Lankes, 2004; Pomerantz, Nicholson, Belanger, & Lankes, 2004). The central question of digital reference, as Lankes (2004) states, is "how can human expertise be incorporated effectively and efficiently into information systems to answer information seekers' questions?" In their report about building synchronicity for digital reference, Connaway and Radford (2011) state that the challenges for the further development of digital reference is that users still do not really know about digital reference services, and users satisfaction plays critical role in the success of a positive digital reference experience. They identified that the two key factors for users' satisfaction are the information provided in the answers and the interpersonal relationships between librarians and the users. They recommended that libraries should cooperate more with peer institutions and other services.

Community-based Q&A and digital reference services can be viewed as two instances of online Q&A (Shah, et al., 2009). Therefore, researchers identified the shared common factors, as well as their

differences. For example, Shachaf (2009b) notes that while librarians are generally regarded as valuable sources for answering more difficult queries, cQA sites are more heavily utilized. Researchers are also interested in the combination of the two services (Shachaf, 2010). Lankes (2004) envisioned a “general digital reference model” that contains a Q&A archive. It could be implemented through the cQA service.

The aforementioned studies all concentrated on English cQA sites and cDR services. There is also much research on Chinese cQA and cDR services (Wang, 2007; Zhang & Yuan, 2009), however, no existing study systematically compares English and Chinese cQA and cDR services.

## Research Design

### Research Questions

Based on the research goal and objectives identified in this study, we propose the following research questions to be answered through experimentation:

- Q1: through the set of questions asked at the selected cQA and cDR sites, what service differences can be obtained in terms of answer quality, answer responsiveness and response time?
- Q2: Do Chinese sites and English sites reveal differences in the answers to Q1?
- Q3: What can be learned from cQA to improve cDR?

### Sites Selected for Our Study

As stated, we selected several representative cQA and cDR services in both Chinese and English. They represent the state of the art of the services we could utilize. These services can be classified into the following four types: three Chinese cQA sites (*Baidu Zhidao*, *Sina iAsk* and *SOSO Ask*); three English cQA sites (*Yahoo! Answers*, *Answers.com* and *MadSci Net*); three Chinese cDR sites (*the Collaborative Reference Service of China's National Science Digital Library*, *Online Collaborative Knowledge Navigation* and *the Collaborative Reference Network of Zhongshan Library at Guangdong Province*); and three English cDR platforms (*QuestionPoint*, *IPL2* and *Ask a Librarian*). Below, we briefly introduce these sites.

*Baidu Zhidao*<sup>2</sup> is an interactive online question and answering platform. Launched in June 2005, it is the most popular Chinese cQA site measured by both usage volume and service maturity. *Sina.iAsk*<sup>3</sup> is a subsidiary online Q&A service of *Sina.com*, which is one of the most popular online portals in China. *SOSO Ask*<sup>4</sup> is an interactive Q&A platform developed by *Tencent.com*. As an integrated service of QQ, the most popular online communication/social network service in China, users of *SOSO Ask* can login with their QQ accounts.

*Yahoo! Answers*<sup>5</sup> is the most popular English cQA site with an active user community as well as well-regarded reputation. *Answers.com*<sup>6</sup> is another very popular interactive Q&A community which claims to have over 60 million user generated questions across 8,000 categories. *MadSci Net*<sup>7</sup> offers over 36,000 answered questions in the domain of natural sciences. It is popular because their questions are answered by scientists, educators and engineering from all over the world.

*The Collaborative Reference Service of China's National Science Digital Library*<sup>8</sup> is a well known service provided by the National Science Library of China. Users can obtain reference services through three methods: live chat, completing a reference request form and phone-based reference. *Online Joint Knowledge Navigation*<sup>9</sup> is a cooperative service led by Shanghai City Public Library (another famous library in China), and includes public libraries, academic libraries, and research libraries in the Shanghai region as well as libraries from other cities in China. *The Collaborative Reference Network of Zhongshan*

<sup>2</sup> BaiduZhidao: <http://zhidao.baidu.com>

<sup>3</sup> Sina.iAsk: <http://iask.sina.com.cn>

<sup>4</sup> SOSO Ask: <http://wenwen.soso.com>

<sup>5</sup> Yahoo! Answers: <http://answers.yahoo.com>

<sup>6</sup> Answers. Com: <http://www.answers.com>

<sup>7</sup> MadSci Net: <http://www.madsci.org>

<sup>8</sup> The Collaborative Reference Service of China's National Science Digital Library: <http://www.csdl.ac.cn>

<sup>9</sup> Online Joint Knowledge Navigation: <http://zsdh.library.sh.cn:8080>

*Library at Guangdong Province*<sup>10</sup> is a library cooperative consortium led by Zhongshan City Library in Guangdong Province and includes libraries from all over China. It has one of the largest Chinese digital resources, and offers free online reference services and remote delivery service to people in China.

*QuestionPoint*<sup>11</sup> is a well known global collaborative digital reference platform that has a very large group of participants and offers a wide range of services. It is managed by OCLC and the Library of Congress of United States. As a collaborative service, users of *QuestionPoint* can direct a question to their local library, and the answers are provided by the librarians with expertise in the relevant subject areas, regardless of their actual location. In our study, we chose the “Ask a Librarian” service offered by the Library of Congress. *IPL2*<sup>12</sup> is currently maintained by the School of Information Science and Technology at Drexel University, and it is based on a well-received online digital reference website developed by Michigan University in 1995. *IPL2* combines IPL (Internet Public Library) and LII (Librarians’ Internet Index). *Ask a Librarian*<sup>13</sup> is a virtual reference system developed through the cooperation of the local university libraries and public libraries in Florida. Over one hundred librarians work together to offer this service to their users.

Table 1: Four types of questions on three different domains

Factual questions	芒德尔•托宾效应最早是在哪篇文章中被提出? In which paper was the idea later called Mundell-Tobin effect first published?	迄今为止, 诺贝尔文学奖已有多少位获奖者? How many people have won the Nobel Prize for Literature up to now?	世界图书首都评选是从哪一年开始的? From which year did the selection of “World Book Capital” begin?
Enumerative questions	根据最新统计数据, 中国有哪些企业进入世界五百强前十名之列? According to the latest data, which Chinese corporations are among the top ten of the world's top five hundreds enterprises?	在所有诺贝尔文学奖得主中, 有哪些人是从南美洲来的? Among all the Nobel Literature Prize laureates, who were from South America?	世界性的图书馆组织有哪些? What international library organizations are there?
Definition questions	什么是流动性补偿? What does compensation for liquidity mean?	什么是泛文学? What does pan-literature mean?	什么是iSchool? What is iSchool?
Explorative questions	全球经济复苏还需要多长时间? 为什么? How much time is still needed for global economy to recover? Why?	博客对大众文学有哪些影响? What impacts have the blogs made on the popular literature?	数字图书馆的快速发展会给实体图书馆带来哪些方面的重大变化? 为什么会有这些变化? What important changes will the rapidly developed digital libraries bring to traditional libraries? And why there are these changes?

## Study Design

The research presented consists of a study based on sampling method, whose purpose is to obtain first-hand, focused evaluation of the selected sites. To guarantee adequate coverage for the

<sup>10</sup> The Collaborative Reference Network of Zhongshan Library at Guangdong Province: <http://www.ucdrs.net>

<sup>11</sup> QuestionPoint: <http://www.questionpoint.org>

<sup>12</sup> IPL2: <http://www.ipl.org>

<sup>13</sup> Ask a Librarian: <http://www.askalibarian.org>

study, we selected four types of commonly asked questions: factual questions whose answers are about certain specific items, enumerative questions whose answers should contain all the related points, definition questions whose answers contain a definition of certain concept and explorative questions which are related to some complex issues that often lack definite answers. At the same time, we chose three different domains that are relatively diverse: economics, literature and library science. Therefore, in total, we issued 12 questions to each cQA or cDR site (see Table 1). Considering that there are both English and Chinese sites, all questions are submitted either in English or in Chinese accordingly. When conducting experiments on those Q&A sites, we asked the questions one-by-one according to the regulations of those sites, whereas during interactions with cDR sites, we tested the request form reference service because of its closer resemblance to cQA than the live chat reference service. Since MadSci Net only accepts questions related to natural sciences, we had to redesign the questions specifically for this system: 1) What is the fastest bird in the world? 2) How many types of conventional clean energy are there? 3) What is SOFC? and 4) Why does America always suffer from hurricane? When the correctness and quality of the obtained answers were judged, the authors and their student helpers looked at printed encyclopedias, Wikipedia and online fact books for answers to factual, enumerative and definition questions, and consulted domain experts on answers to explorative questions. This study started on July 14 2010 and finished on August 25 2010: thus, it lasted for 43 days.

## Results Analysis

### Chinese Experiment Results Analysis

Table 2 shows the number of correct answers and the total number of returned answers for each of the questions. In total, we received 43 answers for the 12 questions asked at the cQA sites; on average 3.58 answers per question. This average number is much smaller than that for the most popular questions on these cQA sites. The reason might be because our questions are more or less related to academic topics. However, that number is still higher than that of answers received from the cDR sites (a total of 29 answers for the same 12 questions with an average of 2.42 answers per question). This means that the cQA sites provided on average one more answer for each of the 12 questions than the cDR sites. In terms of the number of correct answers, cQA produced 33 out of 43 (76.7%), whereas cDR had 23 out of 29 (79.3%). So in summary, the cQA sites were more effective than cDR in eliciting the number of answers, but cDR sites had a higher level of accuracy in their answers.

When evaluating the responsiveness and answer quality based on question types, factual questions generated the lowest number of answers (5 answers for 9 questions) from the cQA sites. This might be due to some nature of the questions themselves. For example, the economics question received no answers from the three sites at all. Our factual questions might be difficult in finding answers for the users in these sites: only 4 questions were correctly answered. In contrast, the cDR sites produced 8 answers for the 9 questions, of which only one is wrong.

The numbers of total returned answers and correct answers to our enumerative questions from the three cQA sites were 13 and 11 (so the accuracy rate is 84.6%), and that from the three cDR sites were 8 and 7 (so the accuracy rate is 87.5%). Similarly, the three cQA sites produced more answers than the three cDR sites on the definition questions (14 vs. 8), and more correct answers (10 vs. 7), but the accuracy rate of the answers was lower (71.43% vs. 75%). These differences are consistent with the literature which notes that the experienced staff at cDR sites have higher information literacy skills, and stronger abilities in searching for information in particular domains.

To our surprise, although the answers for the explorative questions from the cQA sites were similar to those of other types of questions (a total of 11 answers with 8 of them correct), the responses from the cDR services were really low. Only 6 answers were returned, of which 2 were correct. The low accuracy rate of the answers from cDR might be related to our criteria for judging the answers: we count the articles that readers cannot obtain as incorrect answers because common users often cannot access certain databases to download the paper. However, the low response rate from the cDR sites really deserves further study in the future. Maybe it is because the explorative questions we asked are not suitable for these digital references?

Table 2: Number of correct answers/total number of answers to the Chinese questions

questions		cQA sites			cDR sites		
		Baidu Zhidao	Sina .iAsk	SOSO Ask	The Collaborative Reference Service of China's National Science Digital Library	Online Joint Knowledge Navigation	The Collaborative Reference Network of Zhongshan Library at Guangdong Province
Factual questions	Economics	0/0	0/0	0/0	0/1	1/1	0/0
	Literature	0/1	1/1	1/1	1/1	1/1	1/1
	Library science	0/0	1/1	1/1	1/1	1/1	1/1
Enumerative questions	Economics	1/1	1/2	2/2	1/1	1/1	0/0
	Literature	0/0	1/1	2/2	0/0	1/1	1/1
	Library science	1/2	1/1	2/2	1/1	1/1	1/1
Definition questions	Economics	1/1	1/1	2/2	1/1	1/1	1/1
	Literature	1/2	1/2	1/2	0/0	1/1	1/1
	Library science	1/2	1/1	1/1	1/1	1/1	0/1
Explorative questions	Economics	0/0	1/1	3/3	1/1	0/1	0/0
	Literature	1/2	0/0	1/2	0/0	1/1	0/1
	Library science	1/2	0/0	1/1	0/1	0/1	0/0

Table 3 summarizes the collected data including the number of answers from each site, the time it took to answer the questions, rate of correct answers, and ranking of the systems based on the correct answer rate.

Table 3 shows that SOSO Ask and Online Joint Knowledge Navigation are ranked as the top two Chinese services. SOSO Ask responded relatively quickly (the shortest response time among the three cQA sites) and produced the highest number of answers. Thus, it provided faster service as well as higher quality service. Online Joint Knowledge Navigation provided answers to all of the 12 questions, even though the answer accuracy rate is not as high as SOSO Ask. Its answering time was very short too. In contrast, although the Collaborative Reference Network of Zhongshan Library at Guangdong Province had the shortest answering time among all three cDR services, these answers suffered from low quality. After examining the answers provided by the Collaborative Reference Network, our impression is that some answers are too simple or coarse, and that the quality depends too much on the training of individual librarians. However, we acknowledge that their service was still better than that of non-professionals. In our study, another surprising finding is that cQA sites were not (as people had expected) faster at providing answers when compared to the cDR sites. The time to answer of the cQA sites to certain questions could be much faster; however, the overall answering time was comparable for both types of services because some questions posted in cQA sites were answered late or even did not receive any answer at all.

Table 3: Evaluation of the Chinese Sites

rank	system/Q&A websites	number of questions that received answers (out of 12 questions)	number of correct answers/ total number of answers	correct answer rate (%)	answering time (average over all returned answers)
1	SOSO Ask	8	17/19	89.5	1 day, 20 hours and 3 minutes
2	Online Joint Knowledge Navigation	12	10/12	83.3	3 days
3	Sina.iAsk	8	9/11	80	13 days, 19 hours and 5 minutes
4	The Collaborative Reference Service of China's National Science Digital Library	9	7/9	77.7	7 days
5	The Collaborative Reference Network of Zhongshan Library at Guangdong Province	8	6/8	75	8 hours
6	Baidu Zhidao	8	7/13	53.8	6 days and 15 hours

Table 4: Number of correct answers/total number of answers to the English questions

questions		cQA sites			cDR sites		
		Yahoo! Answers	Answers.com	MadSci Net	Library of Congress	IPL2	Ask a Librarian
Factual questions	Economics	0/0	0/0		1/1	1/1	0/0
	Literature	1/1	0/0		1/1	1/1	0/0
	Library science	0/0	0/0		1/1	1/1	0/0
	Natural Science			0/0			
Enumerative questions	Economics	1/1	0/0		0/0	1/1	0/0
	Literature	1/2	0/0		0/0	1/1	0/0
	Library science	1/1	0/0		1/1	1/1	0/0
	Natural Science			0/0			
Definition questions	Economics	1/2	0/0		0/0	1/1	0/0
	Literature	0/1	0/0		0/0	1/1	0/0
	Library science	1/1	0/0		1/1	1/1	0/0
	Natural Science			0/1			
Explorative questions	Economics	2/2	0/0		0/0	1/1	0/0
	Literature	0/1	0/0		0/0	1/1	0/0
	Library science	2/3	0/0		0/1	1/1	0/0
	Natural Science			0/0			

## English Experiment Results Analysis

Table 4 shows the results for the six English systems. The results are organized based on the sites and four question types.

Again to our surprise, two of the five English services did not produce any answers to our questions. Within the three cQA sites, only *Yahoo! Answer* generated multiple answers to some of our questions (15 answers to 10 of the 12 questions). *Answers.com* did not return answers to any of our 12 questions. We only asked 4 questions at the *MadSci Net* site, but only one was answered, which was not correct. Among the three cDR services, *IPL2* dutifully provided one and only one answer to each of our questions, which were all correct. *Library of Congress* handled all three of our factual questions well, but produced only one answer to each of the other types of questions. *Ask a librarian* was even worse: it did not return any answers at all.

There was only one answer to the factual questions from the 3 cQA sites, whereas the response rate and correct answer rate of the cDR were both 100% except for *Ask a Librarian*. This again demonstrates that cDR services have more reliability in providing services.

*Yahoo! Answer* produced four answers to the three enumerative questions, three of which were correct. The three cDR sites also produced four answers, all of which were correct. The correct answer ratio to the definition questions from the cQA sites was 2 out of 4 whereas that from the cDR sites was 4 out of 4. This shows that the cDR sites had a higher quality of answers.

The correct answer ratio to the explorative questions on the cQA sites was 4 out of 6, and that of the cDR sites was 3 out of 4. Again, the level of responsiveness and the correctness of the answers both depended on the strong performance of a single service, which in the case of cQA was *Yahoo! Answers*, and that of cDR was *IPL2*. Specifically, *IPL2* answered correctly all the questions we proposed to them.

As with the results for the Chinese systems, we summarize the data from the English systems, and rank the systems based on the correct answer rate (see Table 5).

Table 5: Evaluation of the English Systems

rank	systems or sites	number of questions that received answers (out of 12 questions except MadSci.Net which was 4 questions)	number of correct answers/ number of answers	correct answer rate (%)	answering time
1	IPL2	12	12/12	100	14 days
2	Library of Congress	6	5/6	83.3	17 days
3	Yahoo! Answers	10	10/15	66.7	2 days
4	MadSci Net	1	0/1	0	/
5	Ask a librarian	1	0/0	0	/
6	Answers.com	0	0/0	0	/

*IPL2* is the best online service we have encountered in this study. It not only answered all of our questions with the highest possible correct answer rate (100%), its librarians gave us answers with detailed and accurate information. They even provided resolution steps to the problems and screening methods for examining the collected information. The reference service at the *Library of Congress* only answered half of the questions with a very long answering time. But it offered remote document delivery service for free, which is rare among the reference services. Among all of the English cQA sites, *Yahoo! Answers* has the fastest answering speed, and the largest number of answers. However, the quality of its answers is not as good as *IPL2* and *Library of Congress*. *Answers.com* and *Ask a Librarian* produced a negligible level of answer or response. One reason for the poor performance in *Answers.com* might be that it has many users asking questions, so our questions might not be the ones that users would like to answer. However *Yahoo! Answers* is an even more popular cQA site, and we received answers from that site. *Ask a Librarian* might primarily serve only local people. *MadSci Net* did not give us much service at all.



## Comparison between Chinese and English Results

Before the experiments, we hypothesized that there could be service variations between the Chinese sites and the English sites due to their language and cultural differences. Our results demonstrate that this hypothesis is both true and false to some degree.

Although in different languages, the sites we studied exhibit many similarities. For example, using *Yahoo! Answers* as the representative of English cQA sites to compare with the three Chinese cQA sites, all four of them performed well on enumerative questions, definition questions and to some degree explorative questions, but poorly on factual questions particularly economics. Similarly the cDR sites in both languages were more reliable in providing their services, and produced higher quality answers even though the total number of answers was smaller in comparison to that of the cQA sites. Also, among the four types of questions, the cQA sites from both languages produced slightly better quality answers on factual questions and enumerative questions, and slightly lower quality answers to definition and explorative questions. However, the number of answers to the factual questions was much lower than those to other types of questions. Similarly, the cDR sites in both languages performed almost identically among factual, enumerative and definition questions, but poorly on explorative questions both in terms of answer quality and the number of answers.

However, we do see some differences between the sites in the two languages. First of all, probably due to our authors' background, our questions to the Chinese sites produced more responses from both Chinese cQA and Chinese cDR sites, whereas two English cQA sites and one English cDR site did not answer our questions at all. In addition, although the English cQA site *Yahoo! Answers* answered our questions in a timeframe comparable to the shortest response time among the Chinese sites, the two English cDR sites were among the longest response time of all of the tested sites. Their time was at least double of the longest response time of the Chinese cDR sites. Maybe it is due to the fact that both *IPL2* and *Library of Congress* have very busy reference services.

## Discussion

### Evaluation of Answers' Quality

Considering the overall experiment results, the cQA sites produced more answers in a shorter time. This is closely related to these sites' greater numbers of users, and higher level of participation. Among the four types of questions, the cQA sites are better at enumerative questions and definition questions in terms of the number of answers and answer quality. The possible reason for this is that these two types of questions benefit from collective wisdom, and more answers can offer a higher likelihood of getting the correct answers to the questions. However, for questions requiring professional and factual knowledge, users in these sites may not want to spend their time in searching for the answers without a reward, so these types of questions would generate fewer responses (such as in factual questions) or less accurate answers (such as in explorative questions). Therefore, cQA sites are probably better suited for answering questions about everyday life or questions with easy answers. We also noticed that some users in the cQA sites just copied and pasted answers to explorative questions from different sites or composed responses simply based on their own knowledge without conducting more thorough research.

Because often only one librarian in a cDR site is allocated to answer a question, there are limited numbers of answers and less answering time the librarian can manage. Therefore, cDR sites often return lower number of answers and take longer time to deliver the answers. However, with much more authority and extensive information sources, cDR sites can produce higher quality answers. The limitations on cDR also include that some questions were ignored by reference librarians in some cDR sites, which cannot be easily compensated as in cQA sites by a large number of people. We also noticed that reference librarians, probably due to training, like to offer related resources in their answers rather than answering the questions directly. This helps to establish the authenticity and authority of the answers, but it sometimes frustrates the users who cannot easily access the identified resources.

In summary, we think that the advantages of cQA sites include large user groups, highly participative activities, and strong interactions. However, there are also some limitations such as information of different qualities and the shallowness of some answers.

The advantages of cDR systems are that they feature rich and reliable reference resources, and high literacy skills of reference librarians. But they also have limitations such as slow response speed and smaller numbers of answers.

### **Inspirations for Libraries from Online cQA Communities**

Through our analyses of these experiment results, we think that the library community can learn from the practices of online cQA communities, and develop better reference services along the following angles.

cQA sites make all of their questions and answers openly available on their websites. Both the questioning and answering processes are open as well. Previous questions and answers are accessible through either browsing or searching. Considering that cDR sites still lack human resources, it might be a reasonable solution to make the cDR reference process and results as open as possible. Of course, we acknowledge the privacy concern from both the users' and librarians' point of view. However, some reference questions are identical to those asked in cQA sites, so they can be made public.

Another benefit of making as many reference questions and their answers openly available is to take advantage of the commenting, tagging and discussing functions that are commonly available in social web 2.0 environments. This not only helps to enrich the answers, to encourage deeper post-reference services, but also makes it possible to develop reward mechanisms that have been demonstrated to be very effective in community-based Q&A sites. Of course, we acknowledge the complexity and caution of applying that idea in a library setting.

Our study shows that cQA sites can produce answers of reasonable quality to some types of questions. Considering the time delay in providing cDR services, would it be possible to explore the usages of cQA answers in cDR services? This not only helps to hasten the answering time, but also helps to integrate more closely the cooperation between cQA and cDR services.

Our results show that reference services have great advantages in solving complex professional problems, but they cannot handle the same number of questions as cQA sites received, nor do they provide the same level of users' participation as in cQA sites. This reflects the idea that cDR is still suffering from a lack of use and awareness in society. Could we learn from successful practices of hosting library-related Facebook pages and YouTube videos, and suggest that some high quality cDR services make them available in well-known cQA sites? This would modernize the image of library reference services and make cDR be recognized by a broader community, particularly groups of younger users. In addition, cDR has the great advantage of experts and information resources which cQA sites cannot compete with, so libraries will have greater potential if they make good use of this advantage. Perhaps cDR may even consider fully integrate the cDR services into cQA sites, so that the strengths of cQA can be combined with the strengths of cDR services.

Although outside of the scope of this study, many cDR sites do provide instant reference services to their users so that the users can get direct and timely online services within a short time limit. This would help to set up cDR sites as different and better service than cQA sites, so it behooves cDR sites to continue to maintain and further explore instant reference services.

We do find that IPL2 is a model cDR service in terms of answer quality and responses to our questions. We hope that it can continue to expand its services to even higher levels, and that other cDR services can learn from IPL2.

### **Limitations of Our Study**

We want to make notes on several limitations of our study. First, the number of our study samples is really small considering the popularity of cQA sites and many other cDR services. Although the sites we selected are among the most popular or recognizable, more wide range of sampling would enhance our results and insights. Second, although it helped us to make direct cross-site comparisons, our research method (using a small set of questions we composed) runs the risks of bias with small samples. As we mentioned in result analysis, our selected questions and our native language might trigger or prevent some responses from the English sites. We intend to examine further on these services using naturally occurred questions and answers recorded in their transaction logs. The outcome of that future study would be a good addition. Third, it would be better to have a survey associated with the questions we

asked so that some reasons behind certain reactions from the sites (such as lack of returned answers to our questions) can be better explained.

## Conclusions

Community-based Q&A (cQA) and collaborative digital reference (cDR) services can be viewed as two examples of online Q&A; thus, the study of their similarities and differences provides interesting topics for researchers. In this paper, we examined their connections and differences through a sampling research method. We selected a set of famous cQA sites and well-known cDR sites, and utilized them with carefully designed questions that cover four common question types and three domains. In order to fully take advantage of the authors' background, we studied both Chinese and English cQA/cDR sites. Our results show that the cQA sites produced more answers in a shorter period, which might be due to these sites' significant numbers of users and their high level of participation. Among the four types of questions, the cQA sites are better at enumerative questions and definition questions, but questions requiring more professional and factual knowledge generated fewer responses (such as factual questions) or less accurate answers (such as explorative questions). Therefore, cQA sites are probably better suited for answering questions about everyday life or questions with simple answers.

Our results with cDR sites show that the number of answers produced by these sites are relatively low and their time delays are often higher in comparison to that of cQA sites. This is compensated for by the expertise of librarians, by the authority and extensive information sources under their control, so that the cDR sites in the end can produce higher quality answers. However, we did notice that some librarians, probably due to training, like to offer related resources in their answers rather than answering the questions directly. This helps to establish the authenticity and authority of the answers but sometimes frustrates the users who cannot easily access the identified resources.

In our discussions, we hypothesize that integrating cQA functions or characteristics into cDR services, will further improve users' satisfactions with cDR services.

Our future work includes the ideas mentioned in the discussions, such as more extensive exploration of the answering of explorative questions in these two types of services, and careful examination of the reasons for the lack of responses from certain sites. More importantly, we would like to implement some discussed ideas that integrate cQA functions into cDR services.

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